# A PRELIMINARY COMPARISON OF SELECTION BY MULTIPLE TRAIT CULLING LEVELS AND BEST LINEAR UNBIASED PREDICTION[1]

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## SUMMARY

One generation of selection was used to compare two methods of selection: a Multiple Trait Culling Levels (MTCL) procedure and a Best Linear Unbiased Prediction (BLUP) procedure based on an animal model. Genetic evaluation involved 14 traits in six White Leghorn strains. There were significant, but small genetic gains for most of the traits selected and some important correlated traits for both procedures. Results of BLUP and MTCL selection differed for four traits: body weight, residual feed consumption, egg specific gravity and Haugh units. These differences appeared to be due to different economic emphasis.

## INTRODUCTION

This study was designed to empirically compare a Multiple Trait Culling Levels (MTCL) selection scheme with a Best Linear Unbiased Prediction (BLUP) procedure based on an animal model. Genetic evaluation by BLUP is a relatively recent technology with many desirable statistical properties. However, a BLUP procedure has not been directly compared with other multiple trait selection methods, except theoretically. This report will describe the comparison of two selection procedures, MTCL and BLUP, after one generation of selection.

## MATERIALS AND METHODS

### Animals

White Leghorn strains from three genetic base populations were used. They were derived from strains of the Animal Research Centre (ARC), Ottawa (Gowe and Fairfull, 1984, 1985, 1986; Fairfull et al., 1983, 1986). In the reproduction of the 1982 hatch, selection was relaxed and related strains previously selected were recombined. Two generations of random mating followed. In each of three genetic bases, the 1985 hatch was divided at random within full-sib family to form two strains which were selected. Four unselected control strains were maintained, one from each of the three bases plus a fourth genetic base. The selected strains were each reproduced with 30 sires and 210 dams (7 dams mated to each sire) with about 1050 hens (5 female progeny per dam) housed. The control strains employed a pedigreed random mating scheme (Gowe et al., 1959) using 100 sires and 200 dams per strain.

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## Selection

Two methods were used for selection: a MTCL procedure and a BLUP animal model procedure for multiple traits. Results of MTCL have been described in Gowe (1977), McAllister (1977), Gowe and Fairfull (1984, 1985) and Fairfull and Gowe (1990). BLUP estimates of breeding values in the base generation were calculated using mixed model procedures (Henderson and Quaas, 1976; Henderson, 1984). One line from each of three genetic bases was evaluated using MTCL selection and the other line used BLUP with a profit function (for seven traits - see below), for a total of six selected lines.

A total of 14 traits were evaluated: fertility, hatchability, brooding, rearing and laying viability, hen day rate of egg production from age at first egg to 357 days of age (d) (HDR1), residual feed consumption (RFC), age at first egg (AFE), body weight at 365 d (MBW), and egg weight (EW2), egg specific gravity (SG2), Haugh units (HU2), blood spots and eggshell shape at 350 d. Breeding values for seven traits were estimated using BLUP: HDR1, RFC, AFE, EW2, SG2, MBW and HU2. In the BLUP selected lines, the remaining traits were culled using MTCL procedures.

## Statistical Analysis

Deviations of the selected strains observations from the mean of the four control strains were analyzed using the model:

$$Y_{ijk} = u + M_i + G_j + MG_{ij} + e_{ijk},$$

where u is the population mean,
$M_i$ is a fixed effect due to method of selection, i = 1, 2,
$G_j$ is a fixed effect due to generation, j = 0, 1,
$MG_{ij}$ is an effect due to the interaction of M and G, and
$e_{ijk}$ is an effect particular to the $k^{th}$ observation.

## RESULTS AND DISCUSSION

Analyses of deviations from controls are shown in Tables 1 and 2. Analyses of fertility, hatchability, viability, blood spots and egg shell shape which were selected using the same procedures in all selected strains are not shown or discussed. The differences due to method indicate that minor differences occurred due to the establishment of strains within genetic bases. There were significant changes between generations (genetic gains) for survivor hen day rate of egg production, hen-housed egg production, age at first egg, body weight, egg weight, egg specific gravity, Haugh units, and blood spots although hen day rate of selection candidates did not change. With the exceptions of age at first egg and body weight, the changes were modest (Tables 3 and 4). BLUP and MTCL selection differed (GxM) for four traits: body weight, residual feed consumption, specific gravity and Haugh units. It appears that BLUP put more emphasis on body weight and residual feed consumption, and less emphasis on specific gravity and Haugh units than MTCL selection.

Table 1. Variance analyses of deviations from unselected control strains for hen day rate of selection candidates and hen-housed egg production.

| Source | Hen Day Rate df | to 357 d | Hen-Housed Egg Production df | to 357 d | to 497 d |
|---|---|---|---|---|---|
| Generation (G) | 1 | 20.5 | 1 | 10479** | 151681** |
| Method (M) | 1 | 4.4 | 1 | 3630** | 13949** |
| GxM | 1 | 57.3 | 1 | 4 | 280 |
| Residual | 11617 | 112.8 | 11686 | 250 | 863 |

**P<.01.

Table 2. Variance analyses of deviations from unselected control strains of survivors[a] for hen day rate of egg production, age at first egg, mature body weight, residual feed consumption and egg quality.

| Source | df | Hen Day Rate to 357d | Hen Day Rate to 497d | Age at First Egg | df | Body Weight at 365d | df | Residual Feed Consumption ($x10^{-3}$) |
|---|---|---|---|---|---|---|---|---|
| Generation (G) | 1 | 161.4* | 17745** | 4343** | 1 | 52784** | 1 | 22048** |
| Method (M) | 1 | 77.3 | 472 | 2358** | 1 | 30146** | 1 | 405 |
| GxM | 1 | 43.5 | 1 | 145 | 1 | 14555** | 1 | 2912** |
| Residual | 10700 | 38.0 | 66 | 122 | 10698 | 598 | 10552 | 110 |

| Source | df | Egg Weight at 350d | Specific Gravity at 350d | Haugh Units at 350d | df | Blood Spots 350d |
|---|---|---|---|---|---|---|
| Generation (G) | 1 | 937** | 4303** | 3620** | 1 | 2040** |
| Method (M) | 1 | 1 | 350** | 1672** | 1 | 555 |
| GxM | 1 | 0 | 440* | 940** | 1 | 0 |
| Residual | 10700 | 16 | 24 | 30 | 10683 | 63 |

[a]Survivors are hens that lived to the end of test (497 d) and laid at a minimum rate of 20% in each third of the laying year after AFE.

*P<.05.

**P<.01.

Table 3. Means and standard errors (S.E.) of Best Linear Unbiased Prediction (BLUP) and Multiple Trait Culling Levels (MTCL) selected strains and of unselected control strains for hen day rate of selection candidates (HDR1), and hen-housed egg production to 357 d (HHP1) and to 497 d (HHP5).

| | BLUP | | | | MTCL | | | | CONTROL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1985 | | 1987 | | 1985 | | 1987 | | 1985 | | 1987 | |
| | Mean | S.E. | Mean | S.E. | Mean | S.E. | Mean | S.E. | Mean | S.E. | Mean | S.E. |
| HDR1 | 85.2 | 0.21 | 85.0 | 0.19 | 85.1 | 0.20 | 85.2 | 0.19 | 78.7 | 0.29 | 78.6 | 0.31 |
| HHP1 | 176 | 0.5 | 182 | 0.5 | 175 | 0.6 | 181 | 0.5 | 155 | 0.7 | 159 | 0.7 |
| HHP5 | 277 | 1.0 | 283 | 0.9 | 275 | 1.1 | 282 | 0.9 | 234 | 1.3 | 248 | 1.4 |

On the basis of results from the first generation of selection, genetic gains for BLUP and MTCL are similar. The differences that exist do not seem to be due to the method of genetic evaluation, but are likely due to differences in economic emphasis.

Table 4. Survivor[a] means and standard errors (S.E.) of Best Linear Unbiased Prediction (BLUP) and Multiple Trait Culling Levels (MTCL) selected strains and of unselected control strains for hen day rate of egg production to 357 d (HDR1) and to 497 d (HDR5), age at first egg (AFE), body weight at 365 d (MBW), residual feed consumption (RFC), feed conversion (CONV) and egg quality[b].

| | BLUP | | | | MTCL | | | | CONTROL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1985 | | 1987 | | 1985 | | 1987 | | 1985 | | 1987 | |
| | Mean | S.E. | Mean | S.E. | Mean | S.E. | Mean | S.E. | Mean | S.E. | Mean | S.E. |
| HDR1 | 87.0 | 0.12 | 86.7 | 0.11 | 86.7 | 0.13 | 86.7 | 0.11 | 81.5 | 0.19 | 81.1 | 0.22 |
| HDR5 | 82.7 | 0.16 | 82.9 | 0.14 | 82.3 | 0.18 | 82.5 | 0.15 | 73.5 | 0.25 | 76.1 | 0.24 |
| AFE | 150 | 0.26 | 143 | 0.15 | 151 | 0.3 | 144 | 0.2 | 159 | 0.3 | 154 | 0.3 |
| MBW | 178 | 0.46 | 171 | 0.48 | 179 | 0.5 | 177 | 0.5 | 184 | 0.6 | 184 | 0.7 |
| RFC | 807 | 5.5 | 856 | 5.9 | 786 | 7.8 | 901 | 6.6 | 895 | 6.3 | 890 | 8.1 |
| CONV | 2.28 | .006 | 2.24 | .006 | 2.30 | .006 | 2.28 | .006 | 2.52 | .011 | 2.53 | .013 |
| EW2 | 60.7 | 0.08 | 60.5 | 0.07 | 60.7 | 0.08 | 60.5 | 0.07 | 58.3 | 0.13 | 58.4 | 0.12 |
| SG2 | 84.1 | 0.09 | 82.8 | 0.09 | 84.2 | 0.09 | 82.1 | 0.09 | 81.9 | 0.12 | 79.0 | 0.13 |
| HU2 | 85.4 | 0.10 | 84.8 | 0.11 | 85.1 | 0.11 | 83.4 | 0.11 | 82.5 | 0.15 | 79.9 | 0.16 |
| BS2 | 2.3 | 0.16 | 2.1 | 0.16 | 1.8 | 0.15 | 1.6 | 0.14 | 2.7 | 0.22 | 3.4 | 0.28 |

[a] Survivors are hens that lived to the end of test (497 d) and laid at a minimum rate of 20% in each third of the laying year after AFE.
[b] EW2 = egg weight, SG2 = egg specific gravity, HU2 = Haugh units and BS2 = blood spots, all at 350 d.

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